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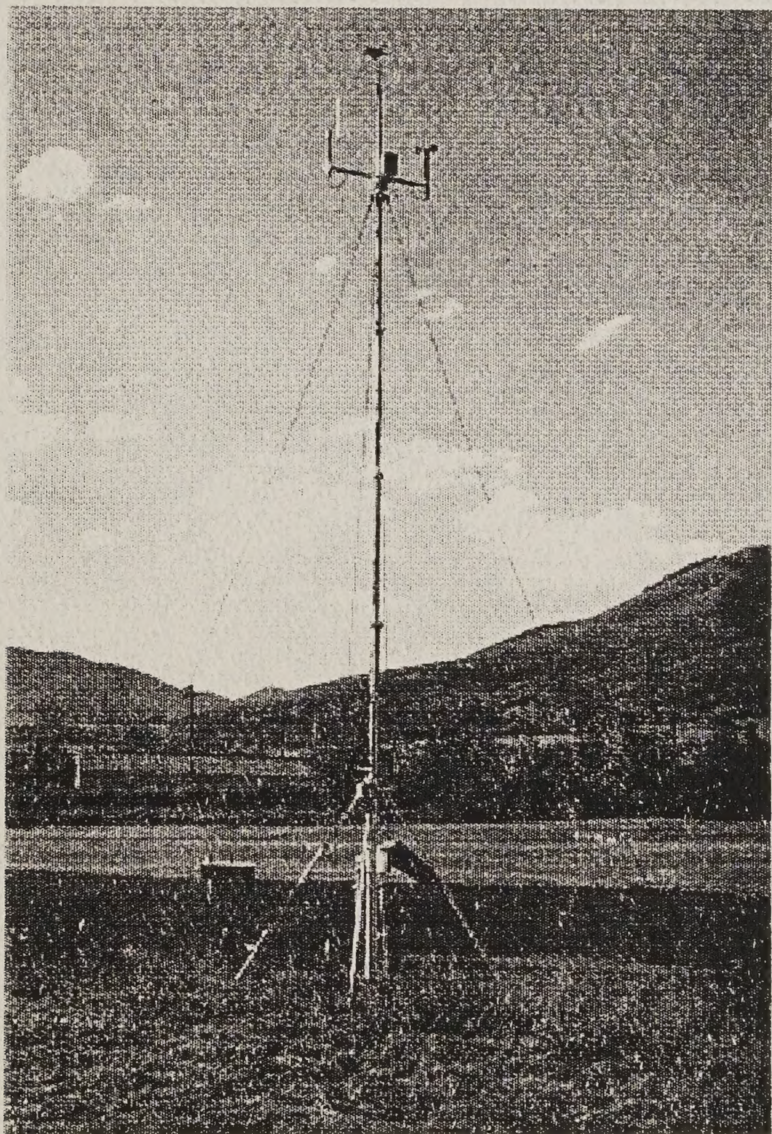
THE STATUS OF FSCBG AND RELATED MODEL DEVELOPMENTS - A 1996 UPDATE



FHTET 96-17
September 1996

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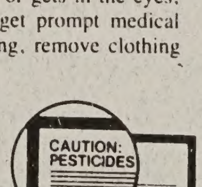
Pesticides used improperly can be injurious to human beings, animals, and plants. Follow the directions and heed all precautions on labels. Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides where there is danger of drift when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment, if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S Environmental Protection Agency, consult your local forest pathologist, county agriculture agent, or State extension specialist to be sure the intended use is still registered.



EMCOT weather station deployed by MTDC to support the Utah aerial spray project. Parley's Canyon, Utah. Photo by John Barry 1991.

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The Status of FSCBG and Related Model Developments - A 1996 Update

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SUMMARY

This technical memorandum summarizes the continuing role played by the USDA Forest Service Cramer-Barry-Grim (FSCBG) model in the development of GypsES (the gypsy moth decision support system developed by USDA Forest Service Forest Health in Morgantown, WV), SpraySafe Manager (the herbicide decision support system developed by USDA Forest Service Forest Health Technology Enterprise Team and New Zealand Forest Research Institute), and AgDRIFT (the aerial drift model developed by the Spray Drift Task Force, a consortium of 38 agricultural chemical companies selling products in the United States).

Continuum Dynamics, Inc. began working with the USDA Forest Service in the early 1980s, first on the development of the AGDISP (AGricultural DISPersal) model, with Robert B. Ekblad, MTDC, Missoula, MT, as the Contracting Officer's Representative (COR), then beginning in 1989 on the continuing development of FSCBG (Forest Service Cramer-Barry-Grim), with John W. Barry as the COR. A recent report by Teske (1995) summarized the then-present status of these two models, and the anticipated areas of usefulness of FSCBG (with AGDISP included as its near-wake model). These areas included:

1. Maintaining FSCBG as a stand-alone model on a personal computer;

2. Extending the applicability of the model into real-time simulation during aircraft spray missions;

3. Assisting the U. S. Environmental Protection Agency (EPA) and the industry-based Spray Drift Task Force (SDTF) in the development of a regulatory near-wake drift model for agriculture (AgDRIFT);

4. Assisting the Canadian Spray Drift Task Force in assessing FSCBG as their regulatory model;

5. Porting FSCBG into the gypsy moth decision support system GypsES through its Spray Advisor;

6. Porting FSCBG into the cooperative USDA Forest Service and New Zealand decision support system SpraySafe Manager; and

7. Continuing to foster partnerships in both the public and private sectors.

These areas of extension are consistent with the approach of using computer models to predict the fate in soil and water of aerially released spray material (as briefly summarized by Barry and Riley 1993), and find their basis in the development of the FSCBG model itself (Cramer et al. 1972; Dumbauld, Bjorklund and Saterlie 1980; Bilanin et al. 1989; Bjorklund, Bowman and Dodd 1988; Teske et al. 1993). It can reasonably be stated that in the last two years, all of the above goals have been, or are being, achieved. What remains an open issue – and one to be addressed here – is the role of FSCBG in each of its derivative model applications, specifically decision support systems, and the model development synergism provided by the presence of FSCBG. It is perhaps best then to review the components of each of the models, their similarities, and more importantly their differences.

AGDISP operates on a personal computer interface under the MS/DOS operating system. The program itself is written in Fortran, although the editing and plotting capability are written in Basic. AGDISP solves for the trajectory (and turbulence effects) of each stream from each spray nozzle, with a Lagrangian formulation that requires models for the aircraft wake effect and atmospheric crosswind. The stand-alone AGDISP model contains some graphical capability, although the technique needed to print the resulting plots is primitive by today's standards. The mod 6 version of AGDISP was completed in 1990; very few improvements have been made to it since then. This model has proven to be highly durable, being initially added to FSCBG (as its near-wake model), then providing the basis for AgDRIFT and SpraySafe Manager (as explained below).

FSCBG also operates on a personal computer interface under the MS/DOS operating system. As with AGDISP, FSCBG is also written principally in Fortran, with a

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graphical interface written in Basic. FSCBG contains AGDISP as its near-wake model, handing off to a Gaussian far-wake model (beyond the influence of the aircraft wake) to predict downwind dispersion, drift and deposition. Deposition may also be recovered from the near-wake model. FSCBG contains an evaporation model, a canopy penetration model, generalized receptor geometry, a library of drop size distributions, a library of aircraft, user-defined library databases, and various graphical options including total accountancy and pesticide fate. The next release of FSCBG (version 5) is scheduled for this fall.

GypsES, or more appropriately the Spray Advisor in GypsES (Teske and Curbishley 1994), is a straightforward extension of FSCBG. The scientific subroutines performing the calculations in GypsES are directly the code written in FSCBG, except for additional features and generalizations written only for GypsES. GypsES is written in C (by other programmers) for operation on a Unix-based operating system; consequently, the large difference with FSCBG in GypsES was the need to develop an appropriate user interface to the scientific subroutines. Additionally, a default spray scenario was decided upon by the GypsES Development Team, and this scenario enables the preselection of many of the more difficult entries into FSCBG. In effect, the version of FSCBG in GypsES is an educated improvement to the "Lite" version of FSCBG, the lowest level of operation of the stand-alone model. A library of aircraft types and models, and a library of spray nozzle drop size distributions, are selected from the FSCBG model, but tailored specifically to aircraft spraying for the gypsy moth and to spray materials used against the gypsy moth. Essentially, the entire input to FSCBG has been reduced to a single main screen (Figure 1). The GypsES user selects the block to be sprayed; the block dimensions are passed to the Spray Advisor (FSCBG); the calculation is performed; and the deposition results are returned to GypsES. All graphics are handled in GypsES. Creating this framework constituted the bulk of the time spent to date in implementing FSCBG into GypsES. The advantage of using the FSCBG scientific subroutines as they are configured in FSCBG is that improvements to these subroutines (as envisioned under tasks current) can be transferred into GypsES with minimal changes. The only qualification is that the interface and its calls to the subroutines must be maintained and consistent.

AgDRIFT (Teske et al. 1996) is essentially an extension of the near-wake model AGDISP, and was developed entirely by Continuum Dynamics, Inc. through contract with the SDTF. In this application the subroutines developed in AGDISP had to be configured to be called within the user interface decided upon by the SDTF. The interface is written in Visual Basic for the Windows environment; the scientific subroutines are still in Fortran, but calling procedures dictate changes in how these routines are accessed. The SDTF has made extensive modifications and alterations in how the AGDISP scientific code is used. Principally, AGDISP writes trajectory information into disk files; its companion plotting routine AGPLOT then interrogates these files to develop the desired visual information. In the interest of computer speed, AgDRIFT instead solves for the ground deposition pattern as the trajectory equations are solved; thus, no disk files need to be created. AgDRIFT contains its own aircraft library (patterned after the FSCBG library but containing aircraft specific to agricultural spraying) and an extensive proprietary drop size distribution database. The SDTF has invested in the development of a technique that predicts the drop size distribution (DROPKICK) and is currently validating that model with its drop size distribution database. AgDRIFT is an environmental and regulatory assessment tool developed in cooperation with the EPA. An example of the main AgDRIFT screen is shown in Figure 2 for its Tier III input.

SpraySafe Manager (Teske 1996) was originally an idea suggested by Dr. Brian Richardson of the New Zealand Forest Research Institute (FRI) in discussions with New Zealand timber and agricultural chemical companies, to develop an environment tool for the

operational use of herbicides by aerial application. The interface is written in Delphi for Windows, a Pascal programming language available from Borland (its main screen is shown in Figure 3). The AGDISP scientific subroutines have been carried over into SpraySafe Manager with the same set of caveats as they were into AgDRIFT. The important additional features are the inclusion of dose-response information (currently being gathered by FRI), a cost analysis technique (based on CASPR), and application statistics quite different in approach and appearance from AgDRIFT. FRI intends to market SpraySafe Manager within and outside New Zealand. Through agreement between FRI and USDA Forest Service, the logic contained in SpraySafe Manager will be included in the stand-alone version of FSCBG.

For the most part the three derivative programs share the same technical base: the AGDISP and FSCBG scientific subroutines. AgDRIFT and SpraySafe Manager are based on the AGDISP (Lagrangian) technology; GypsES Spray Advisor is based on the FSCBG (Gaussian) technology. The GypsES, AgDRIFT and SpraySafe Manager applications, however, access these subroutines in slightly different ways, and incorporate their own personalized graphics.

These derivative applications are decidedly different principally in the user interface platform (as a quick check of the three figures will show), which requires careful programming to include the scientific subroutines (in the case of GypsES and SpraySafe Manager, we do not control the programming of the interface but instead write code to be compatible with it). Each of the applications also contains unique features not found in the other codes. All of these similarities and differences must be kept straight whenever improvements are made. Features developed for one of the applications are always considered for the other two, as a way of presenting the largest number of options to the user. Once an option is developed for one application, its development cost for the other two is minimal (its implementation cost into a different interface may not be, however).

Currently, AgDRIFT development is most innovative (and costly), as the model is being converted from its AGDISP history into an environmental and regulatory assessment tool, and an access point to the entire SDTF database. Most of the programming developments in the last year have little to do with modifying the original AGDISP code from which AgDRIFT is derived, and more to do with the user interface, model options, database structure and documentation. Not surprisingly, the library development tools (needed to access any database structure) in Visual Basic are different from those in Unix and Delphi.

SpraySafe Manager development has been handled to date by one month on-site in New Zealand and the use of a dedicated programmer during that time period. As work gears up next spring to incorporate the dose-response database, and to expand the preliminary code written a year ago into a fully operational program, SpraySafe Manager (much as AgDRIFT) will move along its own dedicated development track. Implementation of its further features into FSCBG has not yet been suggested, as it is difficult to assess the time needed to modify undeveloped SpraySafe Manager routines to fit within FSCBG.

The least-involved coding comes with the development of GypsES, as this code is primarily FSCBG with a user-friendly interface. However, several simplifying features in GypsES (for example, the selection of a flight direction, with the program generating all flight lines and placing them within the specified spray block) are unique to GypsES at present, but are anticipated in the version 5 release of FSCBG.

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There has not been, and will not be, any duplication of effort in the development of the scientific subroutines for FSCBG and these three applications. In the one case where the same path was followed, the initial development of AgDRIFT was cost-shared with the U. S. Air Force during the development of FJSIM, the fuel jettison simulation program (Teske 1996). Although tasks may be identified by relatively interchangeable names, the real work is involved in user interface compatibility, library structure, and the development of application-unique features.

In summary, then, the AGDISP and FSCBG technologies, developed initially in the 1970's and early 1980's, are now being successfully ported into several new aerial application tools, including two developing decision support systems (GypsES and SpraySafe Manager). Each of these models has been developed within its own operating system or user interface programming language, yet by design the scientific subroutines are maintained as common as possible across the models. Communicating with each interface, and providing specific programming options, form the differences between GypsES Spray Advisor, AgDRIFT and SpraySafe Manager.

Work of course continues on FSCBG. Its version 5.0 will be released late this fall to all interested users in the User Group (the total number of users is presently 178). This version will include: (1) a discrete canopy option; (2) a canopy library of Eastern hardwoods; (3) extensive additional graphics for enhanced presentation of deposition and total accountancy; (4) a dose-response database; (5) a decision support module; and (6) a near-wake sensitivity module. This version of FSCBG will provide greater graphics capability, and other additional features requested by the User Group. It will also include the Demo version of FSCBG (Curbishley 1995) with three default scenarios to review model operation, and a new and updated user manual.

Any suggestions or questions on the development of the models described in this update report are welcomed.

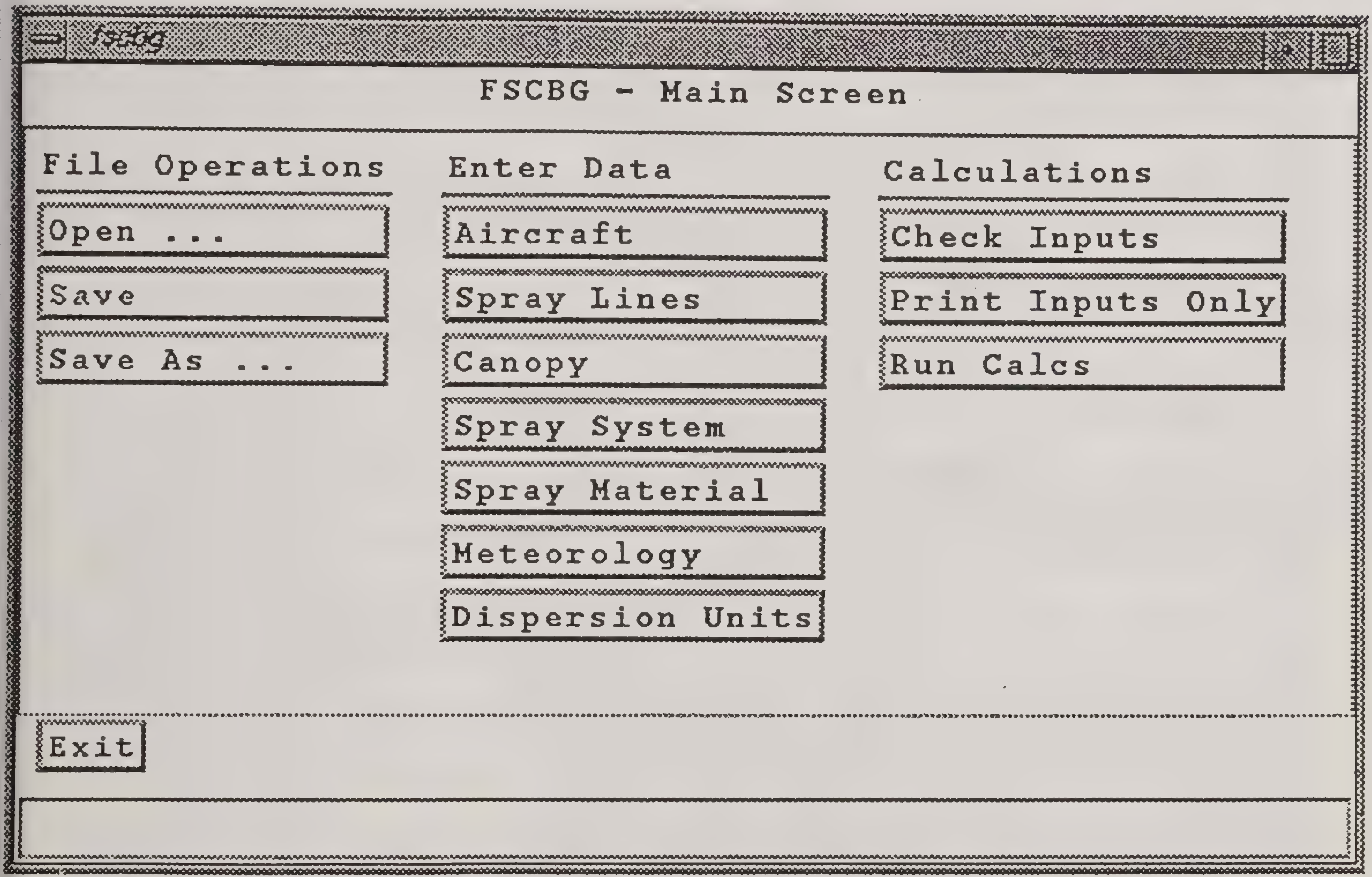

Figure 1. The main input screen to the GypsES Spray Advisor.

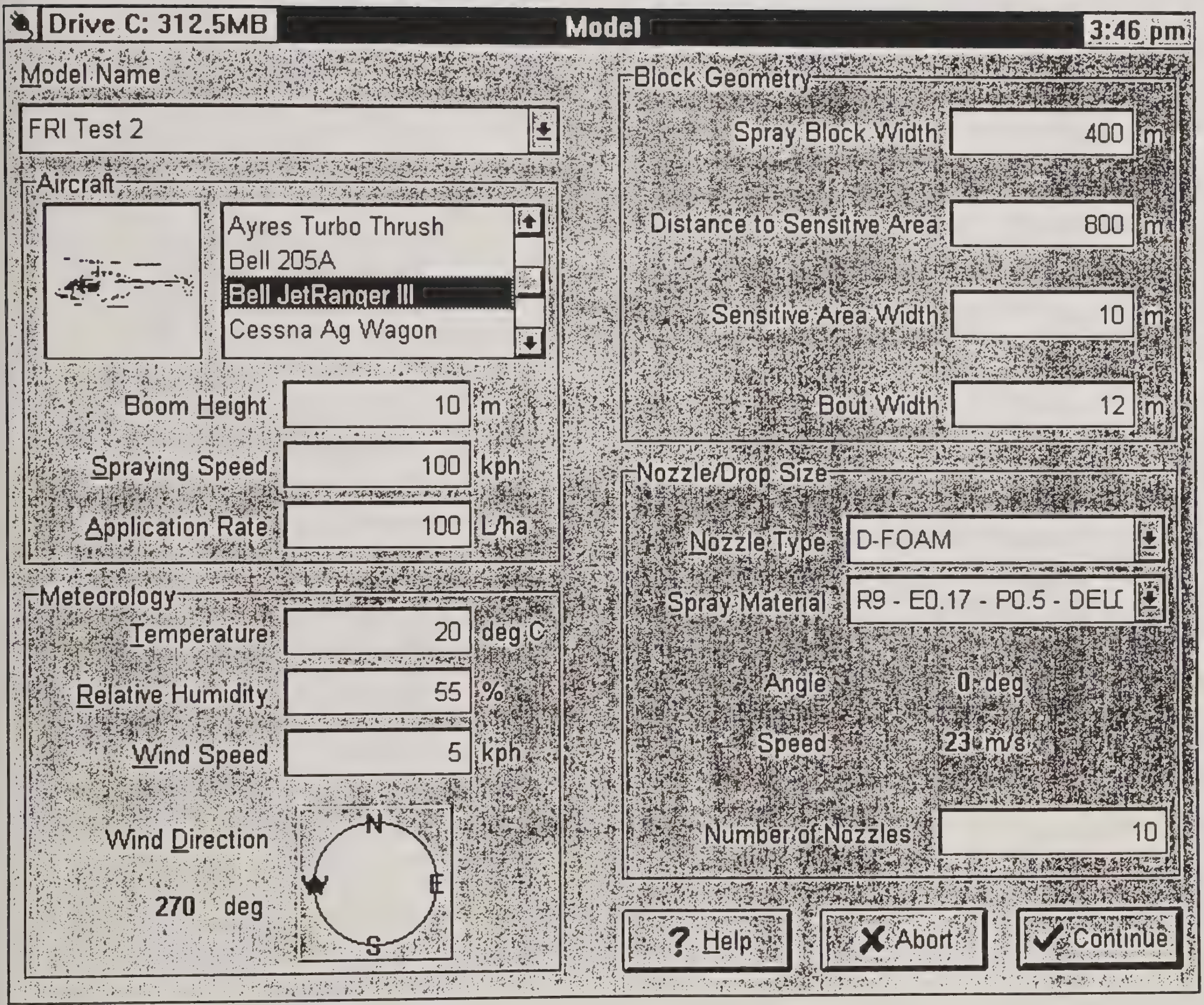

Figure 2. The main input screen to SpraySafe Manager.

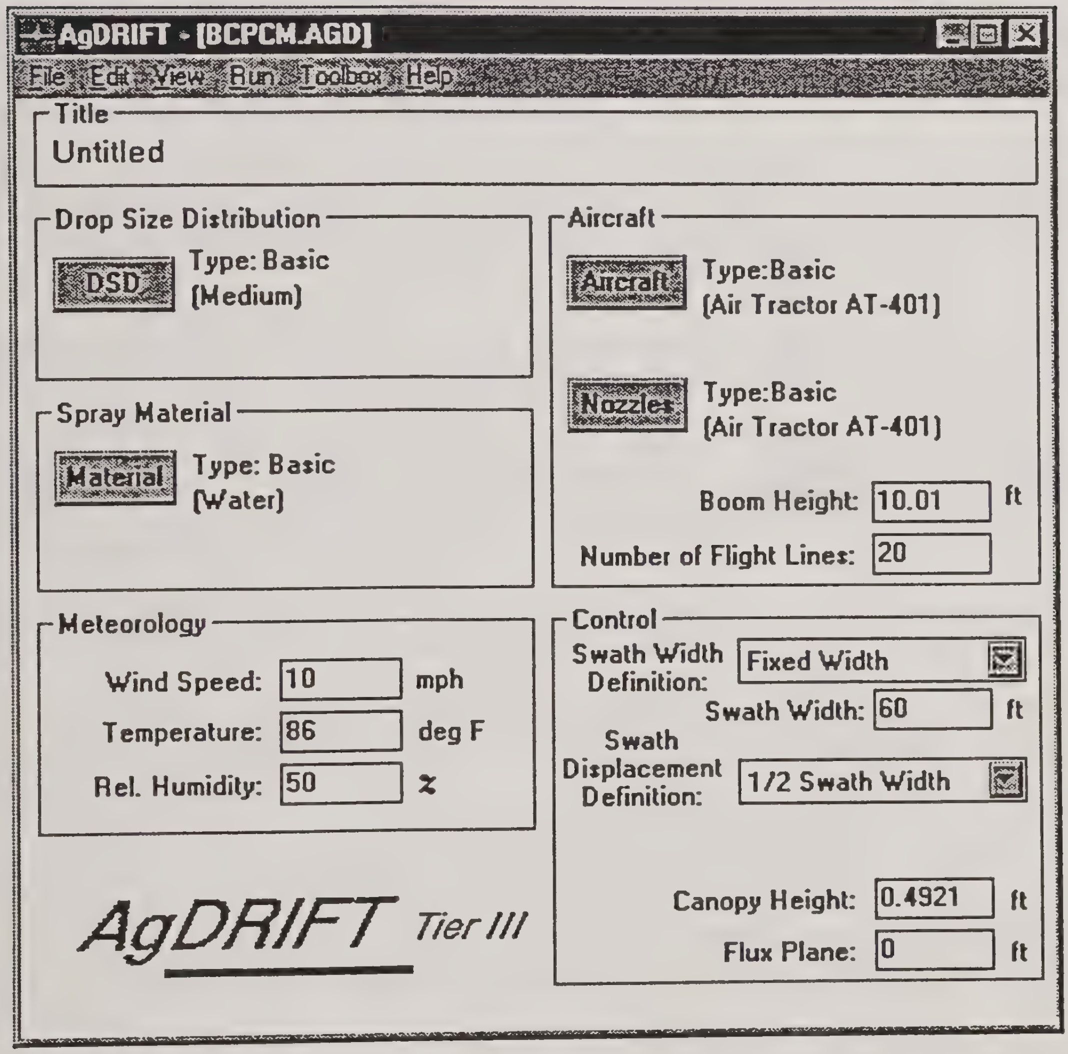

Figure 3. The Tier III input screen to AgDRIFT.

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